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# Framing and Sheathing Floors

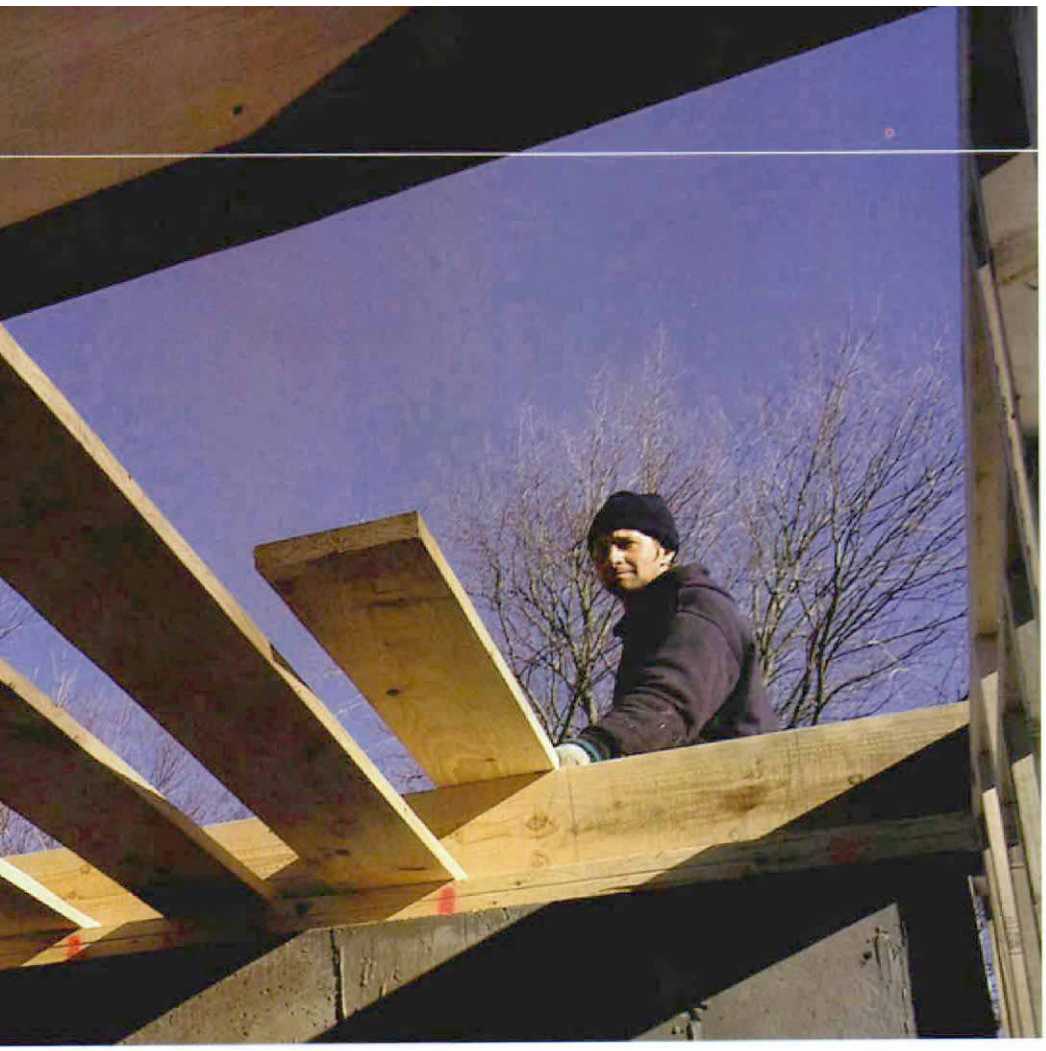
## Is the joist straight or crowned?

## Mark the direction of the crown

## Precut pieces for framing floor openings

A crew member sights each joist to determine the direction of the crown (photo left). An arrow is then drawn on the board to indicate the top edge of the board (photo above).

Using measurements written on the sills during layout, kits containing all the framing members for floor openings such as stairs or chimneys are cut and labeled ahead of time (photo right).



If you do the layout carefully and precut all the joists, the floor will go together quickly like a giant jigsaw puzzle

**by Rick Arnold and Mike Guertin**

We've finished backfilling the foundation, and the mudsills are level and square. Now the real fun begins: saws screaming, hammers humming, sawdust flying. But as anxious as we are to shift into high-gear production mode, we always approach the task of floor framing methodically and thoughtfully. With this strategy, everything goes together right the first time, and the reciprocating saw and the cat's paw stay in the toolbox where they belong.

**A good framing plan streamlines layout and installation—**Before we even think about getting our tools out, and usually before breaking ground, we start our floor on paper with a framing plan (drawing p. 54). Most of the house plans we work from do not include a framing layout, so usually we create our own.

First, we choose the best starting point for the joist layout to minimize the number of joists and the subfloor waste. After looking at how the house is laid out (where the jogs are; how the roof trusses will be laid out; where bearing walls are; where toilets, tubs and showers fall), we decide where to begin the layout. With the house featured in this article, the natural starting point was the front left corner because of the two adjoining sections where the joists changed direction. When in doubt, we usually pick the 90° corner that has the longest uninterrupted legs. All smaller sections are then blended into the larger layout.

On our plans we draw lines for each joist, header, in-floor beam and any special framing details for the house. By using a different colored pencil for each joist length, we can use the plan for accurate material ordering later. When materials are delivered, the joist plan also enables us to direct the different-length 2xs to the appropriate areas of the floor with just a glance.

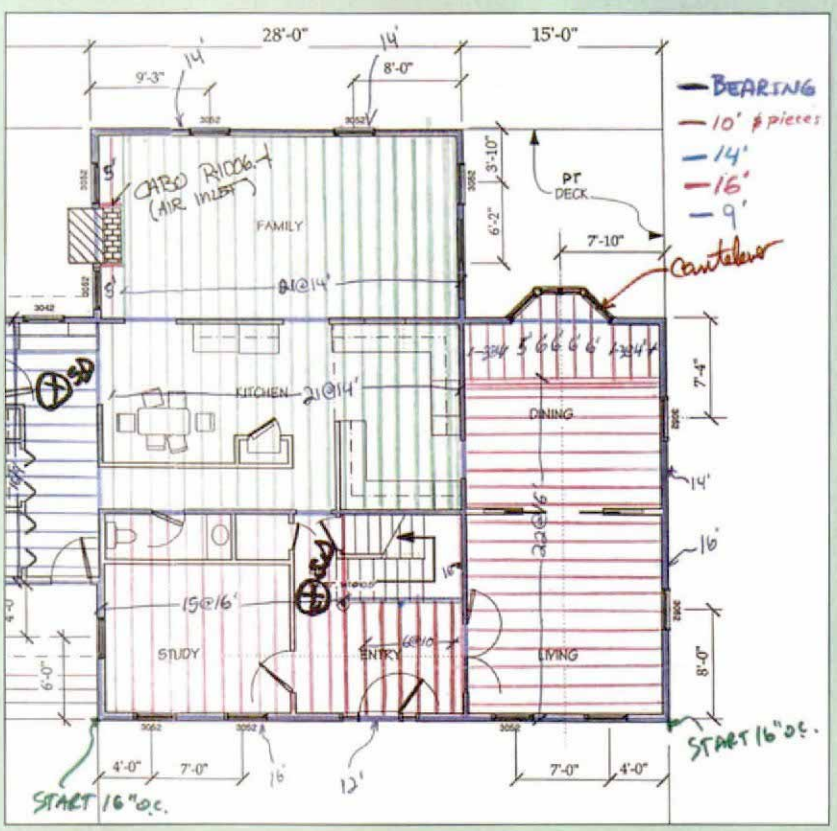
We try to have a preliminary meeting (or at least a couple of quick faxes) with the plumber and heating contractor to identify any joists that might pose a problem with their systems. We can also alert each contractor if we see that both of them expect to fill the same joist bay. By moving a joist a couple of inches to one side or to the other, we sometimes can resolve competition for space. We generally try to avoid having a joist positioned directly below a wall above, and knowing which interior walls will contain vents, drains or ductwork keeps us from placing a joist where it might have to be cut.

The big exception to that rule is where the house has bearing walls running parallel to the floor joists. In those cases we usually double or triple joists under the bearing wall to carry the weight. However, if a plumber or HVAC sub plans to use a bearing wall for drains or ducts, we identify the exact location of the wall on our plan and place the joists under the outside the edges of the wall. Solid blocking is then installed between the joists every 2 ft. or so, leaving space for the systems to come through. We also double the joists beneath large tubs or whirlpools if the fixture is to sit in the middle of the joist span.

**Floor details are spelled out in the layout—**Once the foundation is poured and backfilled, we take great care installing and adjusting mudsills (*FHB* #97, pp. 46-51), carrying beams and basement bearing walls. As we prepare for the floor, everything is kept level and square, and the dimensions on the plans are matched exactly. The closer that we keep the tolerances at the floor-deck stage, the quicker and easier the rest of the

## Assembling the floor frame

**The best floor layout begins on paper.** *Before any lumber is ordered, a detailed framing plan should be drawn. The framing plan exposes potential problem areas such as bearing walls, plumbing or floor openings that might require special attention, and the color code (inset) indicates joist lengths for ordering and then precutting lumber when it arrives.*




**String keeps the layout uniform.** The blue string in the foreground was stretched between the layout marks on the sills. Measurements on the carrying beams are then taken from that line.

house framing will proceed. Before beginning our layout, we string the carrying beams and bearing walls and brace them to keep them straight. These strings are left in place so that we can double-check the walls again after the joists are installed.

To ensure consistency, one crew member does all the joist layout. We begin our layout by marking any special features of the floor deck that interrupt common joist layout. In addition to the chimney and stair openings, the project featured in this article had a cantilevered section, in-floor beams and two areas where the joists change direction.

These special details and measurements are marked with a lumber crayon on the sill plates to alert the crew that the standard layout has changed. Someone following the layout person can then precut the odd pieces, and the installation is easy and obvious. By the way, if an opening in the floor happens to cross a carrying beam, we snap lines across the beam from the marks on the opposite sill plates to keep our measurements consistent.

**Make sure the "X" is on the right side of line**—With all the special features of the deck laid out, the next step is laying out the common joists on the sill plates that run perpendicular to the joists. This floor called for 2x10 floor joists laid out on 16-in. centers.

Starting from the end we determined on our plan, we make marks ¾ in. shy of each 16-in. symbol on the measuring tape. When the entire sill plate or beam is marked off, we go back and make a square line at each mark and draw an X forward of each line. The same procedure is repeated on the opposite side of the house starting at the same end.

Next, we run a line between our starting marks on the sill plates across any intermediate bearing walls or beams. This line gives us a reference point from which to lay out the tops of the bearing walls or the carrying beams (photo above). The uniform starting point helps to keep the joists in a straight line and makes it easy to lay down the subflooring later. Walls and beams are then measured and marked at 16-in. intervals from that point.

The main body of the floor featured in this article is 44 ft. deep. The span is broken into two 14-ft. sections and one 16-ft. section. The joists in the front section will be set ahead of our marks as indicated by the Xs. The middle section will be set behind the mark, and the rear section will be set ahead of the mark like the front. The two outside sill plates get only one line to indicate the location for each joist. But on the two internal beams where joists from adjoining sections will overlap, we add additional lines indicating the outside edges of the joists. (Because we toenail the overlapping joists to the beam after both joists are in place, a single layout line would be hidden beneath the joists.)

**Careful attention is paid to crowns**—While one crew member works on the layout, another sorts and crowns the joist stock (photo bottom left, p. 52). We use only kiln-dried lumber for floor joists. Kiln-dried lumber is less likely than green lumber to shrink or to change shape over time. And because kiln-dried lumber is preshrunk, we don't get problems usually asso-

**Rim joist goes on first.** Before any common joists are installed, a rim joist or band joist is nailed to the outer edge of the mudsills. While one crew member assembles the rim, another transfers the layout up from the sills to the inside face of the rim joist.

**Taking the crown out of a rim joist.** If a rim joist has a severe crown, a relief cut is made that allows the joist to be drawn all the way down to the sill or plate.

**Rolling the joists into place.** After the joists are laid in flat, a crew member rolls them onto their layout marks and nails them to the rim.

**Squash blocks carry loads from above.** Two-by blocks called squash blocks cut slightly longer than the height of the joist help to transfer loads directly to the sill plate or carrying beam. Here, the squash blocks are installed under header-bearing jacks for a sliding door above.

**Tweaking the rim joist.** Before the sheathing goes on, a string is run along the top edge of all the rims that run perpendicular to the joists. The rim is tapped in or out and checked with a square until it is perfectly straight.

dated with green stock, such as drywall cracks, cracked tile, and doors and windows that bind.

Every piece of sawn dimensional lumber has a crown, or a natural curve it takes on after it is cut from a log. We look at each floor joist and mark the direction of its crown with an arrow (photo bottom center, p. 52). Those with excessive crowns (more than ¼ in. in 8 ft.) are set aside to be cut into window or door headers later.

When we get a unit of joist stock that has many boards with crowns of more than in., we grade each joist with an A, B or C designation. Without this extra effort, we could end up with large differences between adjacent joists, creating a washboard effect in the floor and making it difficult to install the tongue-and-groove sheathing. In those cases, the straightest A-joists are used as rim joists and beneath tiled areas such as kitchens and baths. Floor sections that will be covered with hardwood receive B-joists, and C-joists with the biggest crowns are saved for floor areas under carpet or to be cut into headers.

**The rim is installed first**—The rim joist or band joist is toenailed to the outer perimeter of the floor on top of the sill plates or to the top plates of exterior walls (top photo, p. 55). We use 16d nails every 12 in. The rim joists that run perpendicular to the layout prevent the floor joists from rotating. Rim joists that run parallel to the layout close off the floor area along its outside edge. We also install band joists at the interior transition points where joists change direction. Here, they serve as a break point for the edges of the sheathing as well.

We select straight stock for the rim joists so that the crowns don't leave a space between the rim and the plate. If such a space is left, the rim will eventually settle under the weight of the house and cause problems later. When straight stock is scarce, we make a sawcut near the middle of the rim joist about two-thirds of the way across the board (photo bottom left, p. 55). The cut is made in the direction of the crown and lets us fasten the joist down all the way to the plate.

We use the rim joists as in-floor headers over window and door openings in framed walls wherever possible. In-floor headers let us skip the traditional headers and jack studs for openings in exterior walls that run parallel to the joist direction. As long as the rim doesn't break over the opening, a single rim joist can carry the wall weight above short openings. For wider spans such as over a sliding door, we double up the rim over the opening.

This method uses a little less lumber framing, and more important, it increases the thermal efficiency of the wall. On this house we eliminated 24 jack studs (or 3 ft. of solid wood in the walls) and 36 ft. of header stock. All this space can now be insulated.

**Common joists are rolled into place**—We used to take care to cut the rim-joist stock to break exactly on the center of a floor joist. But because the structural wall sheathing extends down to cover and secure the joint, there isn't

## Laying down the sheathing

**Start spreading the glues.** A generous bead of construction adhesive is spread on each joist and on the plywood edge.

**A sledgehammer snugs the sheathing into place.** A 2x block protects the grooves in the edges of the sheathing as it is tapped into place with a sledgehammer.

**A single nail keeps the joist on the layout.** After the sheet has been tacked at the corners, a tape is hooked on the joist tacked to the sheathing, and the other joists are moved until they fall into position. A single nail is then driven to hold the joist on the layout.

any real benefit in doing so. We do check the end of every rim joist to make sure that it's square and trim it if it's not. Square ends are especially critical at the corners to maintain the exact dimensions of the floor deck. Once all the rim joists are in place, we use a framing square or a triangular rafter square to square up all the layout lines from the sills or basement wall plates onto the inside of the rims.

The crew member who crowns the floor joists also checks the end that will butt against the rim joist for square. At the same time, framing members for floor openings are cut from the measurements written on the sill plates and then grouped into kits (photo bottom right, p. 52). For example, the kit for this house's chimney consisted of short rim-joist pieces, headers and cripple joists. When the kit is finished and each piece is clearly marked, it is neatly stacked outside the foundation close to where it will be installed. In areas where joists change direction, the joists have to be cut to length to fit between two rim joists. After being cut, these joists are also stacked near where they will be installed.

We usually assign one crew member to assemble and install the kits for rough floor openings, and the rest of the crew installs the common joists. We first lay all the joists flat on the sill plates and across the carrying beams with all the crowns facing in the same direction (top photo, p. 52). Now we can walk along the outside of the foundation or on top of the plate rolling the joists into place and nailing them to the rim (photo bottom right, p. 55).

If a joist is shorter in height than the rim, we lift and nail it flush with the top of the rim. We go back later and shim under all the short joists. After a joist is nailed through the rim with four or five 16d nails, we drive three toenails through the joist and into the mudsill or top plate. At this point, however, we don't nail the joists at the beams or bearing walls.

After all the joists are nailed in place, we recheck the strings that we set up earlier to straighten all the interior carrying beams and walls as well as any exterior framed walls. When we're satisfied that everything is straight, we walk the beams and nail the overlapping joists to each other again, flushing the tops and shimming under short joists. The overlapping joists are fastened to each other with four or five nails driven at an angle so that the nail points don't stick out the other side. The joists are now set on the outside lines we drew earlier and toenailed to the beams or wall plates with four nails.

According to code (CABO 502.4.1,1995), each joist must bear a minimum of 1½ in. where it sits on a carrying beam, and there must be a positive connection at the joist laps. There are three basic ways to make an approved connection between joists that overlap. The most common way to connect opposing joists is by overlapping them a minimum of 3 in. Another method is using either a wooden block or steel connector plate as a splice across the joist joint. The third method is letting the subfloor sheathing

**Added support at the overlap.** The joist layout changes wherever the joists overlap at an interior bearing wall or a carrying beam leaving part of the edge of the sheathing unsupported. A 2x block is nailed in to hold the unsupported edge (photo above), and the layout is clearly marked for accurate nailing (photo right).

span across the intersection of the joists by a minimum of 3 in.

We never use solid blocking between joists over the beams or bearing walls to transfer loads. Instead, we frame all our walls so that the studs line up directly over the joists. Wherever we have concentrated loads falling on a joist from a wall above, such as jacks carrying a load-bearing header, we install squash blocks, a technique we borrowed from our engineered-I-joist experience (*FHB* #108, p. 53). Squash blocks are 2x blocks cut slightly longer than the height of the joist. They are installed on end beside the joist to help transfer loads to the sill plate or carrying beam (photo left, p. 56). Usually, we install squash blocks after the floor is sheathed, unless we can pinpoint bearing points before. Since we began using squash blocks in conventional floor decks, we've virtually eliminated drywall cracks around door and window openings.

**Don't skimp on the glue for the sheathing**–When all the joists are fastened in place, we double-check all the floor-deck dimensions and take diagonal measurements to make sure the deck is square before we start installing the subfloorsheathing. If the rim joists were installed with square ends at the corners, our measurements are usually close. If the diagonal measurement is off more than ¼ in., we tweak the rim in or out to make the adjustment.

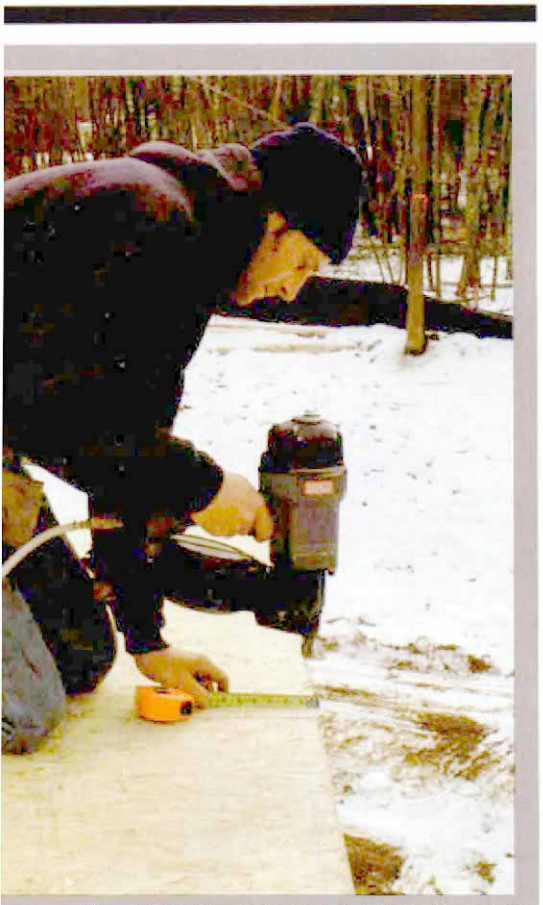
Next, we run strings along all the rim joists running perpendicular to joist runs. We tap the top of the rim in or out as needed and shim if necessary to get the rim joist perfectly straight (photo to right, p. 56). Squaring the joist ends helps to keep these adjustments to a minimum. Rims running parallel to the joists will be straightened later after the sheathing is installed.

To begin sheathing the deck, we measure 4 ft. in at both ends from our starting edge, usually the front of the house. We snap a line and start pumping adhesive onto the joists. From there we snap lines every 47½ in. for a glue guide for each row of sheathing. (We use a 47½-in. measurement because the tongue and the groove cost us ½ in. for each row of sheathing.) The snapped line tells us where to stop the glue for each row to keep glue off our tapes and to keep the joists beyond the sheathing safe to step on.

The first set of sheets is set with the tongues on the rim joist so that we don't ruin them when we bang the sheets into place on successive rows. The first course of sheathing is nailed off completely with 8d ring-shank nails so that it doesn't drift when we drive the next set of sheets in place. We don't glue or nail the edges of the sheets along the rim joist running parallel to the joist direction so that it can be straightened later.

Spreading glue on the joists is an often-overlooked operation. However, we take our gluing seriously. We probably go through many more tubes than most crews, but we believe it's worth the extra labor and material.

Each joist gets a generous bead of glue, and the section of joist where two panels meet gets a bead along both edges of the joist (photo top left, p. 57). We also run a bead of glue down the groove before installing the next row of sheets. The glued tongue-and-groove seams are much stiffer and squeak-free than those left dry. Plus, when glued properly, the sheathing functions



**Straightening the final edge.** When all the sheathing has been installed, a line is snapped 1½ in. from the ends. The rim joist is then moved in or out until it lines up with the end of the tape.

as a vapor barrier, provided that all utility penetrations are carefully sealed.

Framing crews usually just flop the sheets of sheathing down haphazardly onto the joists and slide them over into position. In the process, the glue is smeared and rendered useless, and the joists become a sticky, slippery mess. Instead, we try to lay each sheet down as close to where it is supposed to go and as carefully and gently as possible, which keeps the glue bead where it belongs and keeps the work area neat and safe.

As each sheet is laid down, it is tapped against the adjacent sheets with a 2x block and a sledgehammer (photo bottom left, p. 57). The OSB floor sheathing we use lies flat, and the tongues slide easily into the grooves. When plywood is specified, it's usually necessary to have an extra crew member stand on the seam to flatten the sheet. We adjust the joist that falls under the end of that sheet so that half or about ¾ in. of the joist is left exposed. The outermost corner of the sheathing is then nailed to secure the joist in position. After each course of sheathing is tacked in place in this manner and before the next course is started, we hook a tape onto any of the secured joists and measure, adjust and nail the rest of the joists at their proper 16-in. o.c. position with a single nail at the edge of the sheathing (photo right, p. 57).

We stagger the butt joints between sheets 4 ft. with each successive course. When the layout approaches an area where the joists overlap, we install 2x blocking to support the end of the sheet as needed (photo left, facing page). After we've tacked the whole field of sheets in place, we snap lines to indicate joist locations, taking care to shift our lines where the joists overlap or change direction (photo right, facing page). One crew member then finishes all the nailing so that he can keep track of what's been nailed.

**Tying up loose ends**—Whenever our sheathing runs by an opening such as the stair chase or the opening for the chimney, we either let a small section of sheathing overhang or leave a small uncovered area to begin the next sheet at the edge of the opening. With the bulk of the floor sheathed, we now turn to these details, trimming and filling in as needed.

Because the sheets of sheathing are 47½ in. wide, we end up with a 5-in. void at the end of our 44-ft. house. Rather than sacrificing several sheets of sheathing for their tongues, we cut up scrap pieces of sheathing and use them as fillers. The unsupported joint is not a concern because it will be covered by the 2x6 walls above.

It's rare to have a floor this wide. Most of the houses we do are less than 30 ft. wide, so the sheathing shortfall is usually 3 in. or less. If we don't have enough scrap sheathing to use as a filler strip, we use 1x3 strapping or rip a 1x6 ledger instead, which is cheap and easy to use.

The last step is straightening the rim joists that were left unnailed during the sheathing operation (photo above left). Measuring in 1½ in. from the corners at the ends of the rim, we snap a reference line on top of the sheathing. We now move the rim joist in or out every 4 ft. or so until the distance from our line to the outside edge of the rim measures 1½ in., and we drive a nail at that point. After the edge is tacked straight, we nail it off and trim off any excess sheathing.

The second-story floor deck is built pretty much the same way. However, one step that we take just before lifting the bearing walls that will support the next floor is laying out for the joists on top of the top plate, which is quicker than doing the layout from staging. Once the walls are up, we start the process of installing rims and joists all over again. □

*Rick Arnold and Mike Guertin are contributing editors to* Fine Homebuilding *and residential-construction consultants and builders in East Greenwich, Rl. Photos by Roe A. Osborn.*

## Just say no to bridging

**Here in the Northeast, where construction quality is often judged by how much wood you can pack into a house frame, omitting bridging is a controversial choice. Unless we exceed the 6:1 (depth-to-thickness) ratio in our joist material (2x12) where the CABO code requires blocking or bridging between joists, we almost never install it.**

**To the best of our knowledge, bridging has never been proved to add strength to a floor but it is almost certain to add squeaks. In the past we tried gluing in solid blocks, and for several years we installed steel bridging as an alternative to blocking. We'd install the steel bridging tighter than a guitar string only to return a year later and find it had loosened and was causing squeaks. Even though we use kiln-dried material, the seasonal changes in humidity cause the joists to shrink and swell enough to render any type of bridging worthless.**

**We can just about guarantee squeak-free floor in our homes unless our clients or an architect insists on blocking or bridging. In those cases we are inevitably called back a year later to fix floor squeaks. The remedy for the squeaks usually involves removing any solid blocks or bridging that didn't have to be removed when the plumbers and HVAC installers did their work.**

**Instead, ¾-in; tongue-and-groove: Structural sheathing glued and nailed to the joists is effective at transferring loads to adjacent joists, which is what blocking and bridging are supposed to do. As extra insurance, we install a continuous 1x3 strap nailed to the underside of the joists down the Center of the span in basement to keep the joists from twisting. If the ceiling is to be finished) such as above a living space, we install 1x3 strapping 16.in. o.c. across the whole ceiling—*R. A. and M.G.***